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Improved Imaging of Magnetic Flux Leakage Fields

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Abstract
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IMPROVED IMAGING OF MAGNETIC FLUX LEAKAGE FIELDS

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ABSTRACT

The present detection methods for imaging flux leakage are colored particle, fluorescent particle, Hall detectors and coils. These techniques are limited due to the need for the detector to be in close proximity to the material being inspected. Requirements exist in the Army for both remote sensing techniques and techniques which will allow easier analysis of the detected flux leakage.

ARMY PROBLEM

There exists a need for improved imaging of magnetic flux leakage fields.

Ferromagnetic materials can be inspected for surface and subsurface defects by utilizing the magnetic properties of the material. In this method, the test specimen is magnetized by sending an alternating or direct current through the specimen or by placing the specimen in the field produced by a permanent magnet or an electromagnet. Defects are detected by interrogating the test specimen surface with a probe which detects magnetic field inhomogeneities. If the tested material exhibits adequate magnetic retentivity, the specimen can be inspected after magnetization.

Various probes and support instrumentation are used to detect, sense, and image the magnetic field inhomogeneities at the specimen surface. Small ferromagnetic particles, such as iron oxide powder, are the simplest and most common detectors utilized. To improve visibility, the particles are coated with either a colored or a fluorescent substance. These particles are applied dry or dispersed in a liquid to the test item. The particles accumulate at the site of the magnetic leakage field and produce a visible outline of the discontinuity on the surface of the test item when properly viewed. Water and kerosene are the usual liquids the particles are dispersed in, but room temperature curing rubber is also used to provide a replica casting.

The use of small ferromagnetic particles for imaging magnetic flux leakage fields has the following shortcomings.

1. No quantitiative information is provided about the magnetic flux leakage field.
2. The technique is difficult to adapt to automatic inspection procedures.
3. The particles also accumulate at gravity favored sites.
4. Careful handling is required to not disturb the indication.
5. The interior of cylindrical items such as pipe, gun tubes, and projectile components are difficult to inspect using the magnetic particles as the imaging technique.
6. Indications on specimens with a rough surface finish are difficult to interpret.

Hall detectors, induction coils with and without cores, and some semiconductor devices are used as magnetic probes to sense the magnetic leakage field. These magnetic probes are hand-held or attached to a mechanical scanning mechanism. Coil type magnetic probes require rapid relative motion to the magnetic flux leakage field to generate adequate output signals. For crack detection both the magnetizing field and the probe scanning direction must have components normal to the crack orientation.

A significant amount of hardware has been constructed to examine ferromagnetic items with magnetic probes. Automated and semiautomated systems are used to inspect anti-friction bearings, pipe, gun tubes, projectiles, and similar items with cylindrical symmetry.

The use of magnetic probes to inspect items provides a characteristic signature concerning the flux leakage source. From the magnetic signatures obtained, flaw volume, flaw location, flaw depth from surface, flaw orientation, and flaw width can be determined.

The magnetic signatures can be imaged with an oscilloscope, peak and hold detectors to strip chart recorders, oscillographic recorders and scan converters for video display.

The use of magnetic probes to image magnetic flux leakage fields has the following shortcomings:

1. Some magnetic probes require rapid relative motion.
2. Magnetic probes must inspect very close to the specimen's surface (approximately 0.01").
3. Magnetic probes lend themselves to automated inspection but require complex hardware to follow specimen geometry.

With the advent of coherent single frequency light sources, are there other ways of imaging magnetic flux leakage fields? Do there exist any magneto-optical effects which would be useful for imaging magnetic flux leakage? The advantages of such a technique would be:

1. Remote sensing.
2. Quantitative flaw parameterization.
3. Easier automatic inspection.
4. Easier manual and automatic interpretation.

INTRODUCTION TO CERAMIC NDE

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This morning's session will be devoted to work on ceramics. Ceramics is an area where attempts are under way to try to explicitly predict failure from nondestructive detection and characterization of defects. So we will have a series of talks today, some of which describe the detection and characterization of defects, and others are concerned with the association of those defects to the failure characteristics of the material in an attempt to integrate those two aspects of the failure prediction process.

The first talk will be an overview of the ceramics program to date. This will be presented by Bruce Thompson from the Science Center.

Bruce Thompson (Science Center): Before starting the overview, I would like to conclude my introductory remarks of yesterday with one thing which I neglected to say. If I could have the first slide, please.

On the final day of the program, we have a time period which is indicated as "Open for Informal Working Groups."

Our thinking there was that some people may be able to stay on or even want to stay for the weekend; they might like to use that time to get together and discuss some topics of special interest, and so we have left that time open. More specifically, though, there are a few meeting rooms that are available, and Diane Harris could help you find one if there is a group which would like to continue the discussion of adhesive bonds yesterday or any of the other topics which come up. So please take advantage of that if it suits your interest.

Before going on into my overview, I have another addition to the program. We are fortunate that Bill Reynolds from Harwell has been able to attend the meeting. He was only able to finalize his plans about two weeks ago, so he could not submit a paper. However, they have been doing some very interesting work at Harwell in the area of microfocusradiography. And since the earlier radiographic work was done as a part of this program, and because they have a somewhat more sophisticated instrument that has been able to significantly extend those results, I thought it quite appropriate for him to present a summary of the results that they have obtained.